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MORE ON VARIATION IN THE GENUS LEPIDOCYCLINA (LARGER FORAMINIFERA)

By
W. STORRS COLE

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MORE ON VARIATION IN THE GENUS *LEPIDOCYCLINA* (LARGER FORAMINIFERA)

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ABSTRACT

Although this article is primarily a study of the variation which may occur in *Lepidocyclina vaughani* Cushman (1919*a*), additional data are presented to demonstrate the development of multilocular embryonic chambers in *Lepidocyclina*, and the subgeneric classification of this genus is revised. *Lepidocyclina* is subdivided into the subgenera *Polylepidina* and *Lepidocyclina s. s.* as *Eulepidina* is considered to be a synonym of *Lepidocyclina s. s.* Synonyms of *L. vaughai* are: *Lepidocyclina tournoueri* Vaughan, *not* Lemoine and R. Douvillé, *L. dartoni* Vaughan, *L. tempanii* Vaughan and Cole, and *L. crassimargo* Vaughan. The type localities of certain Oligocene species of larger Foraminifera are reviewed and the associations of species at these localities are analyzed to demonstrate that these faunal associations are widespread in the Caribbean region.

INTRODUCTION

When Vaughan and Cole started their collaboration in the study of larger Foraminifera in 1931, generic definitions and specific descriptions were often based on insufficient data. New names, both generic and specific, were being erected at an astounding rate, in part because older names were not understood, and in part because variation was neither appreciated or understood.

Vaughan (1933*a*, p. 6) was the first American to appreciate the variation which may occur in species of *Lepidocyclina*. He wrote "The amount of variation in many species of orbitoids is bewildering." However, Vaughan (1933*a*, p. 7) had also the philosophy expressed in his own words " . . . it is not always possible to study the variation of a species, but sometimes new species are, in my opinion, justifiably based on a single specimen or on a few specimens."

Vaughan (1933*a*, p. 7) stated "The evaluation of the characters presented by meager material is dependent on the judgment, which is a function of the experience of the investigator." Galloway (1933, p. 469) had the same concept when he included in his definition of species the statement "A group of individuals having substantially the same structure . . . *which are identified by a specialist in that group under the same binomial name*" (italics mine).

These concepts are valid, but clearly point to the fact that there must be a constant review and revision of generic and specific classification as data accumulate. This discourse is a continuation of earlier ones (Cole, 1957*b*; 1958*a*; 1960; 1961*a,b*; 1962; 1963*b,c*) in which the subgeneric classification and selected species of the genus *Lepidocyclina* were analyzed.

There has been some resistance to studies of this kind. Hanzawa (1962, p. 130) wrote among other comments " . . . Cole (1960, p. 101)

postulated that *Nephrolepidina* is synonymous with *Eulepidina*, despite their having been distinguished as two subgenera of the genus *Lepidocyclina* by various authors for half a century." Eames and Clarke (1965) retained the subgeneric name *Pliolepidina* H. Douvillé, 1917, for specimens of *Lepidocyclina* with multilocular embryonic chambers although Cole (1960; 1962; 1963*b,c*) and Sachs (1964) had presented conclusive evidence that multilocular embryonic chambers result from biologic "accidents" either in reproduction or developmental stages of individuals.

However, on the other side Grimsdale (1959, p. 15) wrote "The reality of this tendency among paleontologists—to over-estimate the taxonomic significance of variable characteristics and so to erect superfluous species—is clear from various studies by Vaughan (1933*a*), Vaughan and Cole (1941), and Cole (1944, 1952, 1953, 1957*b*) wherein some 70 described species have beeen reduced by synonymization to about 15 accepted."

Since my initial study (Cole, 1952, p. 29) of *Lepidocyclina vaughani* Cushman from the Panama Canal Zone, over 100 additional thin sections of this species have been prepared. Additional thin sections were made of supposedly valid species which had internal structures similar to those of *Lepidocyclina vaughani*. As a consequence of this study several supposedly valid species are assigned to the synonymy of *L. vaughani*, and an additional revision of the subgeneric classification of *Lepidocyclina* is suggested.

The specimens on which this article is based will be transferred eventually from the Cole collection at Cornell University to the U.S. National Museum.

The localities from which the specimens illustrated were obtained follow.

LOCALITIES OF THE FIGURED SPECIMENS

Antigua

Loc. 1—Half Moon Bay (References: Vaughan, 1923, p. 255; 1924, pl. 33, fig. 9; 1933*a*, p. 32).

2—Hodge Hill (Reference: Vaughan, 1933*a*, p. 27).

Cuba

3—USGS loc. 7552, just south of El Jique, about 6 miles above the mouth of the Yateras River, altitude about 250 feet (References: Vaughan, 1933*b*, p. 354; 1933*a*, p. 22).

Florida

4—Exposure of white to cream-colored, soft limestone in a large sinkhole near Duncan Church, 7 miles southwest of Chipley (References: Cole, 1934, p. 21; Vernon, 1942, p. 58; Cooke, 1945, p. 104).

France

5—Le Sauset, Bouches du Rhône (Reference: Cole, 1961*b*, p. 138).

Mexico

6—Arbol Grande, near Tampico, Tamaulipas, Vaughan's loc. M 12 V (Reference: Vaughan, 1924, pl. 33, figs. 6, 7; 1933*a*, p. 26; Cole, 1961*a*, p. 377).

7—Between kilometer posts 17-18 on the Aguila Petroleum Company's narrow-gauge railroad between Potrero and Tanhuijo, State of Vera Cruz (sta. S.C. M-S 1; W. S. Cole, collector (References: Cole and Gillespie, 1930; Cole, 1961*a*, p. 377; 1963*b*, p. 12).

Panama

8—Quarry of Panama Cement Company, 200 feet north of the Transisthmian Highway and 0.9 mile in direct line northwest of highway bridge across Río Gatuncillo; collectors, J. R. Shultz and W. P. Woodring, 1947 (References: Cole, 1952, p. 7; Woodring, 1957, p. 118).

9—Transisthmian Highway, 2 miles in direct line north-north-west of Río Chagres bridge; collector W. P. Woodring, 1947 (References: Cole, 1952, p. 7; Woodring, 1957, p. 118).

10—Peninsular north of Barbacoas Island, in field 0.8 mile northeast of Lighthouse 13; collectors, S. M. Jones and W. P. Woodring, 1947 (References: Cole, 1952, p. 6; Woodring, 1957, p. 116).

Trinidad

11—Taparo Point (Reference: Vaughan and Cole, 1941, p. 17).

12—Peñal-Rock Road at mile 14, block from a mudflow (Kugler sta. K409*a*) (Reference: Vaughan and Cole, 1941, p. 14).

EXAMPLES OF VARIATION IN SPECIES OF *LEPIDOCYCLINA*

SHAPE AND SIZE OF THE EMBRYONIC CHAMBERS IN *LEPIDOCYCLINA*

The genus *Lepidocyclina* has been subdivided into a number of subgenera largely on the shape and arrangement of the embryonic chambers. However, the validity and necessity for such subdivision has been questioned, or the issue has been evaded.

As early as 1926 Vaughan (p. 394) wrote concerning the American Oligocene species *Lepidocyclina undosa* Cushman "The embryonic chambers are . . . of the Nephrolepidine type. They grade into the Eulepidine type of chambers . . . " Gravell (1933, p. 31) observed concerning Venezuelan specimens assigned to this species "A number of sections of this species show the embryonic apparatus varying from the nephrolepidine to the eulepidine type, making the assignment of this species to either subgenus virtually optional." That the embryonic chambers of this species do vary from nephrolepidine to eulepidine has been substantiated recently by Sachs (1964, pl. 1, figs. 3, 10).

Caudri (1934, text fig. 21*a-m*) illustrated the embryonic chambers of a number of specimens of *L. martini* Schlumberger, an Indo-Pacific Miocene species, which vary from nephrolepidine to eulepidine and trybliolepidine. Caudri (1934, p. 119) wrote " . . . all the smaller nephrolepidine or trybliolepidine *Lepidocyclinae* from the Dutch East Indies belong to one group. . . "

Drooger and Socin (1959, p. 419) wrote concerning the embryonic chambers of the European Miocene species *L. tournoueri* Lemoine and R. Douvillé "It is of various nephrolepidine to 'trybliolepidine' types." This observation is confirmed by their excellent illustrations (pl. 1, fig. 1; pl. 2, all figs.).

Cole (1945, pl. 25, figs. A-C; Cole *et al*, 1960, pl. 12, figs. 2,3) figured specimens of *L. martini* and of *L. japonica* Yabe (Cole, 1963*a*, pl. 10, figs. 9, 13, 14, 18), other Indo-Pacific Miocene species, with nephrolepidine embryonic chambers in some specimens and eulepidine in others. The variation in shape of the embryonic chambers in these two species with relatively small embryonic chambers is duplicated in specimens of *L. radiata* (Martin), an Indo-Pacific Miocene species, with relatively large embryonic chambers (Cole, 1960, pl. 1; 1963, pl. 42).

The embryonic chambers of the American Eocene species *L. chaperi* Lemoine and R. Douvillé vary from nephrolepidine to eulepidine (Cole, 1963*b*, pl. 8, fig. 3; pl. 9, figs. 1-3). Moreover, specimens of this species have been illustrated (Cole, 1952, pl. 10, figs. 1, 5, 7) which have *Lepidocyclina s. s.* embryonic chambers.

The American Oligocene species *L. vaughani* Cushman (Pl. 20, figs. 1-3, 5-7) has embryonic chambers which at one end of the series are similar to the lepidocycline *s. s.* kind and at the other end to large eulepidine or trybliolepidine shape chambers.

The American species *L. yurnagunensis* Cushman (Pl. 24, figs. 5, 8) has been assigned to the subgenera *Nephrolepidina* (Vaughan, 1924, p. 798) and *Lepidocyclina s. s.* (Vaughan, 1926, p. 392; 1933*a*, p. 21; Cole, 1934, p. 24; 1952, p. 22). Cole, (1960, p. 136; 1961*b*, p. 143) at the time the suggestion was made that the subgeneric name *Nephrolepidina* was superfluous, assigned *L. yurnagunensis* to the subgenus *Eulepidina.*

The embryonic chambers (Pl. 24, fig. 8) of certain specimens of *L. yurnagunensis* are similar to those of specimens placed in the subgenus *Lepidocyclina s. s.*, but other specimens (Pl. 24, fig. 5; Cole, 1952, pl. 20, fig. 11; Sachs and Gordon, 1962, pl. 2, figs. 3, 5, 8) are definitely of the nephrolepidine (= eulepidine) kind.

Specimens (Pl. 24, figs. 4, 6, 9) from the Oligocene of Trinidad identified by Vaughan and Cole (1941, p. 75) as *L. tempanii* Vaughan and Cole (= *L. vaughani* Cushman) have embryonic chambers which are not only variable in size but in shape.

Specimens from Guam identified as *L. parva* Oppenoorth [= *L. sumatrensis* (Brady)] (Cole *in* Cole and Bridge, 1953, pl. 9, figs. 10, 11, 18; pl. 10, figs. 11, 12) and from the Eniwetok drill holes (Cole, 1957*c*, pl. 242, figs. 3-20) have embryonic apparatuses which are lepidocycline *s. s.* to nearly typical eulepidine shape.

Several specimens of *L. vaughani* (Pl. 20, figs. 1-3, 6, 7) from one locality are illustrated to demonstrate that relatively large differences in size occur. These same size differences are shown by specimens (Pl. 24, figs. 4, 6, 9) from another locality. However, specimens of *L. undosa* (Pl. 22, figs. 1, 6; Cole, 1934, pl. 4, figs. 4, 5) from one geographic locality may have embryonic apparatuses which are small compared with those of specimens of the same species from another geographic locality (Pl. 22, fig. 7; Cole, 1963*b*, pl. 8, figs. 1, 2). Another species of which sufficient preparations have been made to show the difference in size of the embryonic apparatus is *L. pustulosa* (Cole, 1963*b*, pls. 23-25).

Other illustrations could be presented to demonstrate that the shape and size of the embryonic apparatuses in species of *Lepidocyclina* are extremely variable. Any subdivision of this genus into subgenera must recognize this fact.

SUBGENERA OF LEPIDOCYCLINA

In the "Treatise on Invertebrate Paleontology," Part C, Protista 2 (1964, p. 721) Cole recognized four subgenera of *Lepidocyclina*, namely, *Lepidocyclina s. s.*, *Eulepidina*, *Pliolepidina* and *Polylepidina.* In 1963

during the time this volume of the Treatise was in press Cole restudied *Pliolepidina* and published (1963*b*, p. 18) a revised opinion on the status of this subgenus. The conclusion reached was that *Pliolepidina* H. Douvillé, 1917, was a synonym of *Lepidocyclina s. s.* Gümbel, 1870. Unfortunately, this concept could not be incorporated in the Treatise.

Cole (1963*b*, p. 35) wrote "If *Pliolepidina* is accepted as a synonym of *Lepidocyclina s. s.*, there will be three subgenera, *Polylepidina, Lepidocyclina s. s.*, and *Eulepidina* in the genus *Lepidocyclina*." The specimens on which this reduction in the number of subgenera was based and the interpretations which were made have been published (Cole, 1963*b*, and references cited) and will not be repeated.

The major structural difference in the supposedly valid subgenera is between *Polylepidina* and the other two subgenera. *Polylepidina* has a single, but pronounced, coil of periembryonic chambers which partially surround the embryonic chambers (Cole, 1963*b*, pl. 1, fig. 3). In *Lepidocyclina s. s.* and *Eulepidina* two principal periembryonic chambers are developed, one on each side of the dividing wall between the embryonic chambers (for *Lepidocyclina,* see: Cole, 1963*b*, pl. 1, figs. 1, 2, 4, 5; for *Eulepidina*, see: Cole, 1963*b*, pl. 8, fig. 3; pl. 9, fig. 3; Pl. 21, fig. 7; Pl. 22, fig. 4). This structural arrangement is sufficient to distinguish *Polylepidina* from the other two subgenera.

If *Lepidocyclina s. s.* and *Eulepidina* are to be recognized as valid subgenera, some criterion other than the development of the periembryonic chambers must be found. Thus, the shape and arrangement of the embryonic chambers have been used. *Lepidocyclina s. s.* was defined on the occurrence of two equal, or subequal embryonic chambers, whereas *Eulepidina* had an initial chamber which was either partially embraced or completely enclosed by the second chamber.

A specimen (Pl. 20, fig. 1) of *L. vaughani* has embryonic chambers of the kind recognized as *Lepidocyclina s. s.* This illustration should be compared with the one of *L. pustulosa* illustrated as figure 2, plate 3 (Cole, 1963*b*). This same relationship is demonstrated if the illustration (Pl. 20, fig. 1) of *L. vaughani* is compared to certain equatorial sections of *L. chaperi* (Cole, 1952, pl. 11, figs. 4, 6). Many other species, if sufficient thin sections are available, show the same variation in shape of the embryonic chambers, as do *L. vaughani* and *L. chaperi*, for example, *L. sumatrensis* (see: Cole, 1957*c*, pl. 242, figs. 3-20).

In some species of *Lepidocyclina* the embryonic chambers run the

gamut from lepidocycline *s. s.* to eulepidine of which *L. vaughani* is an example. Other species have embryonic chambers which vary from lepidocycline *s. s.* to nephrolepidine (for example, *L. sumatrensis*). Still other species have embryonic chambers which are more or less consistently of one kind (*L. mantelli* and *L. canellei*).

From the data available I am forced to the conclusion that there is no possibility of separating species into the two subgenera, *Lepidocyclina s. s.* and *Eulepidina*, and, therefore the proposal is made that *Eulepidina* is a junior synonym of *Lepidocyclina s. s.* Thus, the genus *Lepidocyclina* would be subdivided into *Lepidocyclina* (*Polylepidina*) and *Lepidocyclina* (*Lepidocyclina*).

The formerly used sugbeneric names are meaningful as descriptive terms similar to the manner in which goniatitic, ceratitic, and ammonitic are used at present. Kummel (1961, p. 289) wrote concerning these ammonoid names " . . . the terms have no taxonomic or stratigraphic significance, but they are excellent descriptions of the basic suture patterns."

The fact has not been overlooked that the American middle Eocene species *Lepidocyclina ariana* Cole and Ponton has subequal embryonic chambers and that the first American species in which certain specimens have the initial chamber enclosed by the second chamber is the upper Eocene *L. chaperi* Lemoine and R. Douvillé.

From these data alone it would appear that two subgenera could be recognized as there would appear to be evolution with time from lepidocycline *s. s.* embryonic chambers to eulepidine. However, once the variability of the shape of the embryonic chambers from lepidocycline to eulepidine in several species has been demonstrated, the actual shape of the embryonic chambers loses its significance as an evolutionary structure and must be relegated to specific importance only.

The basic structural change in the embryonic apparatus is the development of two principal periembryonic chambers. *Polylepidina* with one major periembryonic chamber has an entirely different arrangement of the periembryonic chambers than the other lepidocyclines have. This is the only evolutionary advance. The change in shape of the embryonic chambers is not constant varying from individual to individual in many species and can not be defined.

MULTILOCULAR EMBRYONIC CHAMBERS

The occurrence of two distinct sets of normal, bilocular embryonic chambers in specimens of *Lepidocyclina* has been established (Zuffardi

Comerci, 1929, pl. 9, fig. 22; Rutten and Vermunt, 1932, pl. 3, fig. 2; Cole, 1963*b*, pl. 4, fig. 6; this article Pl. 21, fig. 6). Specimens have been illustrated which have a single set of trilocular embryonic chambers (Provale, 1909, pl. 3, fig. 18; Cole, 1962, pl. 4, figs. 4, 5; 1963, pl. 14, fig. 6; this article Pl. 21, fig. 5) as well as specimens which have "twinned" trilocular embryonic chambers (Cole, 1962, pl. 4, fig. 1; 1963*c*, pl. 44, fig. 1).

Specimens in which two sets of embryonic chambers occur must have had two nuclei at the time the embryonic chambers developed although the ephebic development in these specimens is similar to that of mononucleate specimens with a single set of bilocular embryonic chambers.

Certain specimens (Cole, 1962, pl. 5, fig. 2; 1963*c*, pl. 45, fig. 1) which obviously developed under the control of a single nucleus have deformed, bilocular embryonic chambers. Sachs, (1964) in a carefully reasoned and well-illustrated study of *Lepidocyclina undosa* with multilocular embryonic chambers, demonstrated that specimens " . . . with mononucleate embryonts in which the initial chamber is so large with respect to the total size of the embryont that it has resulted in the protoplasm of the second chamber being concentrated into a series of small, interconnected lobes resembling chamberlets about the equatorial plane of the initial chamber."

The illustrations which have been cited demonstrate that a mononucleate specimen may develop multilocular embryonic chambers. However, this kind of multilocular embryonic chamber can develop under the control of two or more nuclei. The specimen (Pl. 21, fig. 6) has two distinct and separate sets of bilocular embryonic chambers which are not fused. Another specimen (Pl. 21, fig. 4) from this same sample has two distinct sets of embryonic chambers in which fusion has occurred so that there is interconnection between the second embryonic chambers. A third specimen (Pl. 21, fig. 5) has trilocular embryonic chambers. This specimen has large periembryonic chambers on the periphery of the large chambers at each end and smaller periembryonic chambers at each side of the dividing walls of the central chamber. In addition each of these dividing walls has a stolon near the center.

In the specimen (Pl. 21, fig. 6) the two nuclei either were situated within a single mass of protoplasm so that two sets of bilocular embryonic chambers could develop, or two masses of protoplasm, each with a nucleus, were in close proximity to each other. However, there was sufficient

separation of the nuclei so that two sets of normal bilocular embryonic chambers developed. In the specimen (Pl. 21, fig. 4) the spacing of the nuclei was such that the development of the walls of the second embryonic chambers at the zone of juxtaposition was inhibited, thus the two sets of embryonic chambers were interconnected producing in effect a trilocular embryonic apparatus. The specimen (Pl. 21, fig. 5) seemingly developed from two closely associated nuclei in which the central chamber of this set represents the combined initial chamber developed by the two nuclei. The two large chambers on either end of the trilocular set represent the second embryonic chambers, each of which developed under the control of a separate nucleus.

Proof has beeen given that specimens may develop multilocular embryonic chambers either under the control of one or two nuclei. Specimens in which three sets of embryonic chambers are found must develop under the control of three nuclei. The specimen (Cole, 1962, pl. 7, fig. 5) has two sets of bilocular embryonic chambers in association with a large multilocular chamber. A minimum of three nuclei are required to form this association.

Sufficient proof has been presented by Cole (1960; 1962, p. 33; 1963*b*, p. 14; 1963*c*) and Sachs (1964) to show conclusively that multilocular embryonic chambers are only one possible variant in the development of embryonic apparatuses, and, thus, have no value on a subgeneric or higher taxonomic level.

Eames and Clarke (1965), however, argued that *Pliolepidina* H. Douvillé, 1917, is a recognizable genus " . . . possessing a characteristic multilocular nucleus [and] is generically distinct from *Lepidocyclina* (*Lepidocyclina*) Gümbel, 1870 . . ." Moreover, they reject the concept of Vaughan and Cole (1941, p. 65; Cole, 1963*b*) that *L. trinitatis* is a synonym of *L. pustulosa* and that "*Pliolepidina*" *tobleri* represents specimens of *L. pustulosa* which developed multilocular embryonic chambers. The evdence available refutes the postulates made by Eames and Clarke.

HISTORY OF THE SPECIFIC NAMES WHICH HAVE BEEN APPLIED TO *L. VAUGHANI*

Six specific names have been used or applied to American specimens, all of which are referred to *Lepidocyclina* (*Lepidocyclina*) *vaughani* Cushman (1919). These names are: *L. tournoueri* of H. Douvillé, Vaughan, and Cole, *not L. tournoueri* Lemoine and R. Douvillé (1904) (a European

species), *L. verbeeki* of Barker, *not L. verbeeki* Newton and Holland (1899) (an Indo-Pacific species), *L. tempanii* Vaughan and Cole (1933), *L. dartoni* Vaughan (1933), *L. crassimargo* Vaughan (1933), and *L. lehneri* van de Geyn and van der Vlerk (1935).

H. Douvillé (1924, p. 47) identified specimens from Erin Point, Trinidad, as *Nephrolepidina tournoueri* Lemoine and R. Douvillé (1904, p. 19), a European species. Vaughan (1924, p. 798) assigned specimens from Arbol Grande, near Tampico, Mexico, to this species stating it occurred in the Oligocene of Mexico and Trinidad. In 1933 Vaughan (*a*, p. 25) gave a complete description of the Mexican specimens, but he did not mention the specimens from Trinidad. However, Vaughan and Cole (1941, p. 75) definitely assigned the specimens from Trinidad which H. Douvillé (1924, p. 47) had referred to *Nephrolepidina tournoueri* to the synonomy of *L. tempanii* Vaughan and Cole (*in* Vaughan, 1933*a*, p. 26).

Vaughan and Cole (1941, p. 75) stated "Van de Geyn and Van der Vlerk (1935, p. 271, figs. 14, 15) have named a species *Lepidocyclina* (*Nephrolepidina*) *lehneri*. Both the description and the figures are inadequate, but it is possible that this species is a synonym of *L. tempanii*."

Thus, two species were recognized by 1941, if *L. lehneri* is accepted as a synonym of *L. tempanii*, *L. tournoueri* based on specimens from a single Mexican locality, and *L. tempanii* reported from Antigua and Trinidad. Vaughan and Cole (*in* Vaughan, 1933*a*, p. 27) wrote "The main difference in the two species is readily seen in a comparison of the equatorial section. *L. tempanii* has much more elongate equatorial chambers than *L. tournoueri*."

Cole (1952, p. 29) demonstrated that the elongation of the equatorial chambers in Mexican specimens which Vaughan (1924, p. 798; 1933*a*, p. 25) had referred to *L. tournoueri* was equal to that of specimens of *L. tempanii*. Equatorial chambers of Mexican specimens and of topotypes of *L. tempanii* are illustrated on Plate 21, figures 1-3. As this difference in the degreee of elongation of the equatorial chambers was the only criterion by which these species could be separated, Cole (1952, p. 29) concluded that the Mexican specimens represented the same species as those from Antigua and Trinidad which had been named *L. tempanii*. In later studies Cole (1961*a*, p. 388, 391; 1964, p. 141) used the specific name *L. tournoueri* Lemoine and R. Douvillé (synonym: *L. tempanii*) for specimens of this kind.

Species associated with the Mexican specimens of *L. tournoueri* reported by Vaughan (1933*a*) are a "dwarf variety of *L. canellei*" (p. 15) and *Lepidocyclina parvula* Cushman var. *crassicostata* Vaughan and Cole (p. 17) (= microspheric form of *L. canellei*—see: Cole, 1961, p. 384). In addition specimens of *Camerina panamensis* (Cushman) [reported as *Camerina dia* (Cole and Ponton)] occur at this Mexican locality (Cole, 1961*a*, pl. 29, figs. 6,9,10).

Specimens from San Pedro, Peru, originally identified by Barker (1932, p. 278, 279, pl. 16, figs. 2, 3, 5) as *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland, an Indo-Pacific species, were considered by Cole (1952, p. 30) to be typical *L. vaughani.* These specimens were associated with *Miogypsina panamensis* (Cushman).

In 1933 (*a*, p. 36) Vaughan described a stellate species of *Lepidocyclina* as *L.* (*Nephrolepidina*) *dartoni* from Cuba. Cole (1952, p. 27) identified specimens from a single locality in the Panama Canal Zone as *L. dartoni.*

In 1961 Cole (*a*, p. 389) wrote "It should be recognized that in *Lepidocyclina* the stellate pattern is produced only in certain individuals, probably under the influence of ecological conditions, and that this pattern is not genetically produced. Therefore, it does not have value as a specific character."

The specimens of *L. dartoni* (Cole, 1952, pl. 19, figs. 1-8), except for their stellate pattern, are identical with other nonstellate specimens (Cole, 1952, pl. 19, figs. 8-12) which were assigned to *L. tournoueri.* Therefore, *L. dartoni* was placed in the synonomy of *L. tournoueri* (Cole, 1961*a*, p. 388). Additional specimens of *L. dartoni* from Panama (Pl. 22, figs. 2, 3, 5) are illustrated for comparison.

Although by 1961 Cole had suggested that specimens referred to *L. tournoueri, L. tempanii, L. dartoni* and *L. lehneri* represented only one species which he assigned to *L. tournoueri*, he considered that *L. vaughani* was a distinct and readily recognizable species. However, as more extensive faunal studies were completed in the Caribbean area, it became apparent that *L. vaughani* (reported from Antigua, Costa Rica, Carriacou, and Panama) never was found in association with *L. tournoueri* (Mexico, Antigua, Trinidad, and Panama) except for a doubtful occurrence of *L. tournoueri* with *L. vaughani* at a single locality on Carriacou (Cole, 1958*b*, pl. 28, fig. 8).

This seemed surprising inasmuch as these two species of *Lepidocyclina* by associated species of other larger Foraminifera and general stratigraphic position should occur together. Thus, a question was raised whether there were in actuality two species, *L. tournoueri* (= *L. tempanii*) and *L. vaughani*, or whether these specimens represented only one species. An attempt will be made to demonstrate that all of these specimens should be combined under one specific name, *L. vaughani*.

LEPIDOCYCLINA TOURNOUERI VAUGHAN, *NOT* LEMOINE AND R. DOUVILLÉ, 1904, A SYNONYM OF *L. VAUGHANI* CUSHMAN.

Specimens assigned to *Lepidocyclina vaughani* from Panama (Pl. 19, fig. 3) and from Antigua (Pl. 23, fig. 9) have a small, distinct umbo bordered by a wide flange which expands noticeably at the periphery. The lateral chambers are open, large, with slightly curved or straight roofs and floors, arranged in regular tiers with thin, but distinct pillars. The equatorial chambers (Pl. 19, figs. 1, 6; Pl. 20, fig. 5; Vaughan, 1933*a*, pl. 16, figs. 3, 4; Cole, 1952, pl. 21, fig. 5) are markedly rhomboid.

Specimens assigned to "*L. tournoueri*" (Pl. 23, fig. 2; Vaughan, 1933*a*, pl. 13, fig. 2) and "*L. tempanii*" (Pl. 23, figs. 1, 5, 11; Vaughan 1933*a*, pl. 13, fig. 3; Vaughan and Cole, 1941, pl. 39, fig. 6) are not only similar, but also resemble the umbonate part of specimens of *L. vaughani* inasmuch as the lateral chambers and pillars have the same shape and arrangement.

However, in equatorial section specimens identified as "*L. tournoueri*" (Pl. 21, figs. 2, 3; Vaughan, 1933*a*, pl. 13, fig. 2) and "*L. tempanii*" (pl. 1, fig. 5; pl. 3, fig. 1; Vaughan, 1933*a*, pl. 13, figs. 4-6; Vaughan and Cole, 1941, pl. 39, figs. 5, 8) have elongate hexagonal equatorial chambers, at least, in the peripheral zone.

Cole (1952, pl. 20, figs. 1-3; pl. 21, figs. 7, 11, 12) published several vertical sections of specimens of *L. vaughani* from Panama in which the flange either did not develop or had been removed by erosion. These illustrations should be compared with the specimens illustrated as figures 1, 2, 5, 11, Plate 23. There are no differences.

Inasmuch as the embryonic apparatuses in all the specimens under discussion are the same, the only apparent difference is the shape of the equatorial chambers, rhomboid in *L. vaughani* and elongate hexagonal in "*L. tournoueri*" and "*L. tempanii*."

Examination of numerous equatorial sections of *L. vaughani* from one locality (loc. 9) in Panama demonstrated that certain specimens (Pl. 19, figs. 1, 4) develop elongate, hexagonal equatorial chambers which are similar to those of "*L. tempanii*" (Pl. 19, fig. 5) and "*L. tournoueri*" (Pl. 21, figs. 2, 3).

Moreover, many specimens of "*L. tempanii*" (Pl. 20, fig. 4; Pl. 24, figs. 6, 9) and "*L. tournoueri*" (Pl. 24, fig. 7) have rhomboid equatorial chambers similar to those of *L. vaughani* in the zone adjacent to the embryonic apparatus.

Cole (1957, p. 106) suggested that "The shape of any equatorial chamber must be governed by the mass of protoplasm from the surface of which the chamber walls form . . . A slight radial elongation of the mass will produce diamond-shape walls, and slightly greater radial expansion will result in hexagonal shapes . . . The availability of food may be a factor in certain situations, as a smaller supply of food may result in longer extensions of the protoplasm."

The fact once established that many of these specimens have equatorial chambers which vary from rhomboid to elongate hexagonal shape destroys the single criterion by which separate species can be recongized. Thus, specimens referred variously to "*L. tournoueri*", "*L. tempanii*" and other supposedly valid species are in reality *L. vaughani* Cushman.

European specimens (Pl. 23, fig. 6; Cole, 1961*b*, pl. 16, fig. 1; Drooger and Socin, 1959, pl. 1, figs. 1-4; pl. 2, all figs.) of *L. tournoueri* Lemoine and R. Douvillé, 1904, are similar to the American specimens which have been assigned to this European species. Eventually, it may be possible to demonstrate that the American specimens assigned at present to *L. vaughani* represent the same species as the European specimens. If so, *L. vaughani* Cushman, 1919*a*, will become a synonym of *L. tournoueri*.

TYPE LOCALITIES OF CERTAIN AMERICAN LARGER FORAMINIFERA

Table 1 gives the type localities of 12 species of American larger Foraminifera and the species which have been reported in association with the type at each of these localities. Data on the type localities are summarized under each species. American specimens which Vaughan (1924, p. 798; 1933*a*, p. 25) referred to the European species, *L. tournoueri*, are not listed in this section as they are discussed elsewhere in this article.

Table 1.—Type localities of certain American larger Foraminifera and other species associated with the types at these localities.

	Panama Canal Zone			Antigua		Cuba		Trinidad
	Peña Blanca	6021[1]	6025[1]	6862[1]	6869[1]	7548[1]	7664[1]	K482
Camerina panamensis (Cushman)			T					
Heterostegina antillea Cushman	*p	p	p		T			p
Lepidocyclina canellei Lem. and R. Douvillé	T	p	p					
***dartoni* Vaughan							T	
***gigas* Cushman				T				p
parvula Cushman				T				p
***tempanii* Vaughan and Cole				T				p
vaughani Cushman	*p	T					p	
undosa Cushman					T		p	
yurnagunensis Cushman	*p		p			T	p	p
Miogypsina panamensis (Cushman)	*p		T					p
Spiroclypeus bullbrooki Vaughan and Cole								T

[1]USGS locality numbers used in text.

T = type; p = other species reported from type locality.

* At localities in the vicinity of submerged Peña Blanca (see text).

** *L. tempanii* and *L. dartoni* are synonyms of *L. vaughani,* and *L. gigas* is a synonym of *L. undosa.* The names are retained in this table to designate type localities only.

Camerina panamensis (Cushman).—The type of *Camerina panamensis* is *Nummulites panamensis* Cushman (1919*a*, p. 98) from USGS loc. 6025, Panama Canal Zone, a locality in the middle member of the Caimito Formation of the Gatun Lake Area (Woodring, 1957, p. 117). Topotypes have been described and figured by Vaughan and Cole (1941, p. 46, pl. 10, figs. 13, 14; pl. 11, figs. 1-4) and Cole (1952, p. 10, figs. 1-4; 1958, p. 272; 1964, p. 141, pl. 14, figs. 2, 6, 9, 10, 14).

The types of *Heterosteginoides panamensis* Cushman (1919*a*, p. 97, pl. 43, figs. 3-8, *not* figs. 1, 2) (= *Miogypsina panamensis*) are also from USGS loc. 6025. Vaughan and Cole (1932, p. 510) described from this locality *Lepidocyclina* (*Lepidocyclina*) *pancanalis*, a species which Cole (1952, p. 18) considered to be a synonym of *L. canellei* Lemoine and R. Douvillé.

Cole (1952, p. 7) identified from locality 55 (= USGS loc. 6025) *Camerina panamensis* (Cushman) (as *Operculinoides panamensis*), *Heterostegina antillea* Cushman (as *H. israelskyi* Gravell and Hanna and *H. panamensis* Gravell), *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé, *L.* (*L.*) *canellei* (as *L.* (*Lepidocyclina*) *parvula* Cushman), *L.* (*L.*) *yurnagunensis* Cushman, and *Miogypsina panamensis* (Cushman).

Heterostegina antillea Cushman.—The type was described (Cushman, 1919*b*, p. 49) from USGS loc. 6869, Long Island, Antigua. The type description was brief and the illustrations were inadequate with the exception of one transverse section (Cushman, 1919*b*, pl. 5, fig. 1). Vaughan and Cole (1941, pl. 16, figs. 1, 2) published illustrations of two oriented median sections of topotypes.

H. antillea is associated at its type locality with abundant specimens of *Lepidocyclina undosa* Cushman (1919*b*, p. 65), the types of which came from this locality.

Lepidocyclina canellei Lemoine and R. Douvillé.—This species, one of the earliest described American species (Lemoine and R. Douvillé, 1904, p. 20), was based on specimens from Peña Blanca, Panama Canal Zone, a locality submerged by Gatun Lake. Associated species at the type locality have not been reported.

Woodring (1957, p. 29) stated "Foraminiferal soft limestone, such as that at locality 54 *f* doubtless corresponds to the foraminiferal marl of publications issued before the flooding of Gatun Lake." Earlier, Cole (1952, p. 7) wrote "The lithology at locality 53 suggests descriptions of the marl at the submerged locality at Peña Blanca . . ."

Cole (1952, p. 7) identified three species at locality 53 in association with typical specimens of *L. canellei*. They are: *L. yurnagunensis* Cushman (as *L. yurnagunensis morganopsis* Vaughan), *L. vaughani* Cushman, and *Miogypsina panamensis* (Cushman) [as *M.* (*Miogypsina*) *antillea* (Cushman)]. At locality 54 *f* Cole (1957*a*, p. 314) reported *Heterostegina antillea* Cushman, *H. israelskyi* Gravell and Hanna (= *H. antillea* Cushman), *Miogypsina* (*Miogypsina*) *antillea* (Cushman) [=*M. panamensis* (Cushman)], and *Miogypsina* (*Miolepidocyclina*) *panamensis* (Cushman) in association with *L. canellei*.

Lepidocyclina dartoni Vaughan.—In 1933 (*a*, p. 36) Vaughan described a stellate species of *Lepidocyclina* as *L.* (*Nephrolepidina*) *dartoni* from the " . . . northern slope of La Piedra, northeast of Jamaica, northeast of Guantanamo, Cuba, USGS loc. 7664." From this locality Vaughan (1933*b*, p. 354) reported *L. yurnagunensis* Cushman, *L.* (*Eulepidina*) sp. cf. *L. dilatata* (Micht.), a European species, and *L.* (*Nephrolepidina?*) *crassimargo* Vaughan (1933*a*, p. 33), a new species.

The illustrations given by Vaughan (1933*a*, pl. 26, fig. 4; pl. 27, figs. 5, 6; pl. 28, figs. 1, 1*a*) demonstrate that the specimens which he compared with *L. dilatata* are without question *L. undosa*. The specimens identified as *L. crassimargo* are *Lepidocyclina vaughani* Cushman.

Lepidocyclina gigas Cushman.—Large microspheric specimens from USGS loc. 6862 were named *L. gigas* by Cushman (1919*b*, p. 64). Vaughan (1924, p. 799) was the first to suggest that *L. gigas* " . . . is a microspheric form which appears to belong to the same species as *L. undosa* Cushman." In 1933 (*a*, p. 41, pl. 22, figs. 1-4) Vaughan illustrated the internal structure of this form to supplement the external views given by Cushman (1919*b*, pl. 1, figs. 3-5).

USGS loc. 6862 is also the type locality of *L. parvula* Cushman (1919*b*, p. 58) and *L. tempanii* Vaughan and Cole (*in* Vaughan, 1933*a*, p. 26).

Lepidocyclina parvula Cushman.—The types of this species were obtained from USGS loc. 6862 " . . . lower bed at Hodges Bluff, Antigua . . . " (Cushman, 1919*b*, p. 58). The types of *L. gigas* Cushman (1919*b*, p. 64) and *L. tempanii* Vaughan and Cole (*in* Vaughan, 1933*a*, p. 26) were obtained from this locality.

Lepidocyclina tempanii Vaughan and Cole.—The type description of *L.* (*Nephrolepidina*) *tempanii* Vaughan and Cole (*in* Vaughan, 1933*a*,

p. 26) was based on specimens from " . . . near top of Hodge Hill, Antigua, collected by W. R. Forrest . . . [and] USGS loc. 6862, Hodge Point, collected by T. W. Vaughan" (Vaughan, 1933*a*, p. 48). As Cushman (1919*b*, p. 58, 64) based the descriptions of *L. parvula* and *L. gigas* on specimens obtained from USGS loc. 6862, this locality is designated as the type for *L. tempanii*.

Lepidocyclina undosa Cushman.—The types of *L. undosa* Cushman (1919*b*, p. 65) are external views of two sellaeform specimens associated with numerous other specimens of the same kind, and a few specimens of *Heterostegina antillea* Cushman on a slab of foraminiferal limestone from USGS loc. 6869, Long Island, Antigua.

Vaughan (1924, p. 798, pl. 34, figs. 5, 6) illustrated the embryonic chambers of two topotypes, and Vaughan and Cole (1941, pl. 41, fig. 1) figured a vertical section of a topotype. Vaughan (1926, p. 394) was the first to emphasize that the embryonic chambers of this species vary from nephrolepidine to eulepidine in shape.

Lepidocyclina vaughani Cushman.—The type illustrations of *Lepidocyclina vaughani* Cushman (1919*a*, p. 93) are external views of two specimens (pl. 37, fig. 4; pl. 38) from USGS loc. 6021 (= 6673), Panama Canal Zone. These specimens are weathered, therefore the equatorial chambers are exposed in the marginal zone of the test.

Other specimens (Cushman, 1919*a*, pl. 37, figs. 1, 2, 3, 5) from USGS loc. 6255, identified by Cushman as *L. vaughani*, later were named L. (*Lepidocyclina*) *miraflorensis* Vaughan (1923, p. 253). Cole (1961*a*, p. 373) placed *L. miraflorensis* in the synonomy of *L. canellei* Lemoine and R. Douvillé.

Vaughan (1923, p. 254) recorded "*Lepidocyclina canellei* . . . occurs with *L. vaughani* at the type locality . . . " Cole (1952, p. 6, 7) studied larger Foraminifera collected by S. M. Jones and W. P. Woodring, 1947, from locality 43 "One-quarter mile southwest of USGS locality 6021 . . ., the type locality of *Lepidocyclina* (*Nephrolepidina*) *vaughani*, but presumably a little higher stratigraphically in the middle member." At this locality *L. vaughani* was associated with *Heterostegina antillea* Cushman and *Lepidocyclina canellei* Lemoine and R. Douvillé.

Cushman (1919*a*, p. 90, 93) stated that the types of *L. vaughani* (USGS loc. 6021 = 6673) came from the Emperador Limestone. Woodring (1957, p. 116) assigned this locality to the middle member of the

Caimito Formation. The specimens erroneously assigned to *L. vaughani* by Cushman (1919*a*, pl. 37, figs. 1, 2, 3, 5) from USGS loc. 6255 were from the La Boca Formation (Woodring, 1957, p. 125).

Lepidocyclina yurnagunensis Cushman.—Specimens from USGS loc. 7548, 2 miles south of Yurnaguna, Cuba, were named *L. canellei* Lemoine and R. Douvillé, var. *yurnagunensis* Cushman (1919b, p. 57). Vaughan (1924, p. 798), without discussion, listed this variety as *L.* (*Nephrolepidina*) *yurnagunensis*. In 1926 Vaughan (p. 393) stated "*L. yurnagunensis* seems to me to be specifically distinct from *L. canellei* . . . In *L. canellei* the embryonic chambers are strikingly similar in size, and the equatorial chambers are hexagonal." So far this species is the only one recorded from this locality.

Miogypsina panamensis (Cushman).—In the type description of *Heterosteginoides panamensis* Cushman (1919*a*, p. 97) specimens from two localities were figured. The types of *M. panamensis* (Cushman, 1919*a*, pl. 43, figs. 3-8) were from USGS loc. 6025, Panama Canal Zone, a locality in the middle member of the Caimito Formation of the Gatun Lake area (Woodring, 1957, p. 117). The other specimens (Cushman, 1919*a*, pl. 43, figs. 1, 2) were from USGS loc. 6011, Panama Canal Zone, from the Culebra Formation (Woodring, 1957, p. 122), and were referred to *M. cushmani* by Vaughan (1924, p. 813), a species whose type locality is USGS loc. 6012*d*, Panama Canal Zone.

USGS Loc. 6025 is the type locality for *Camerina panamensis* (Cushman) (1919*a*, p. 98) and for *Lepidocyclina pancanalis* Vaughan and Cole (1932, p. 510), a species which Cole (1952, p. 18) placed in the synonomy of *L. canellei* Lemoine and R. Douvillé. *Heterostegina antillea* Cushman and *Lepidocyclina yurnagunensis* Cushman also occur at this locality (see under *Camerina panamensis*, this article).

Spiroclypeus bullbrooki Vaughan and Cole.—The types are from Kugler's loc. K 482, Marac River, Trinidad, West Indies. This is the only known American species. At its type locality Vaughan and Cole (1941) recorded the following: *Heterostegina antillea* Cushman, *Lepidocyclina canellei* Lemoine and R. Douvillé (as *L. parvula* Cushman), *L. tempanii* Vaughan and Cole, *L. undosa* Cushman (as *L. gigas* Cushman) *L. yurnagunensis* Cushman, and *Miogypsina panamensis* (Cushman) (as *M. haukinsi* Hodson).

STRATIGRAPHIC IMPLICATIONS

Specimens identified as *Lepidocyclina vaughani* have been reported from the Panama Canal Zone (Cushman, 1919*a*, p. 93; Cole, 1952, p. 29; 1957*a*, p. 314), Antigua (Vaughan, 1933*a*, p. 33), Carriacou West Indies (Cole, 1958*b*, p. 221) and Costa Rica (Malavassi, 1961, p. 500). In addition, specimens identified by Barker (1932, p. 278) as *L.* (*Nephrolepidina*) *verbeeki* Newton and Holland, an Indo-Pacific species, were considered by Cole (1952, p. 30) to be typical *L. vaughani*.

Specimens assigned to *L. tempanii* were recorded from Antigua (Vaughan, 1933*a*, p. 26) and Trinidad (Vaughan and Cole, 1941, p. 75). American specimens referred to the European species, *L. tournoueri*, were known from one Mexican locality (Vaughan, 1933*a*, p. 25).

Vaughan and Cole (1941) identified 18 species associated with *L. tempanii* at 11 localities in Trinidad. Some 17 species have been identified as occurring with *L. vaughani* at the various localities from which more or less complete faunal identifications have been made. However, these species can be reduced to eight supposedly valid species if known synonyms are evaluated. Table 2 gives the species associated with *L. vaughani* and *L. tempanii* in several geographic areas.

Table 2.—Number of localities in the Caribbean area in which the various species are associated.

	Panama		Trinidad	Carriacou	Mexico
Number of localities analyzed	Bohio	Caimito			
	2	7	11	4	1
Archaias angulatus (Fichtel and Moll)	1	—	—	—	—
Camerina panamensis (Cushman)	—	—	4	2	1
Heterostegina antillea Cushman	1	3	9	3	—
Lepidocyclina cancellei Lem. and R. Douvillé	2	5	9	2	1
**tempanii* Vaughan and Cole	—	—	11	—	1
vaughani Cushman	2	7	—	4	—
undosa Cushman	1	—	7	—	—
yurnagunensis Cushman	1	3	5	—	—
Miogypsina panamensis (Cushman)	2	2	7	4	—
Spiroclypeus bullbrooki Vaughan and Cole	—	—	2	—	—

* *L. tempanii* is a synonym of *L. vaughani*

The association of species (Table 2) shows that "*L. tempanii*" and *L. vaughani* had not been reported in association. Except for *Archaias angulatus* which occurred with *L. vaughani* at one locality in Panama and *Spiroclypeus bullbrooki* which occurred with "*L. tempanii*" at two localities

in Trindad, all the other species occurred with both "*L. tempanii*" and *L. vaughani* at several localities.

Proof has been advanced in this article that *L. tempanii* is a junior synonym of *L. vaughani*. Cole (1967, p. 100) wrote: "Analysis of the structure of the test is the best means of determining species, but species which are recognized should be tested against known geographic and stratigraphic relationships." It is obvious from the association of species (Tables 1, 2) that specimens which were named *L. tempanii* are components of the same larger foraminiferal fauna to which *L. vaughani* belongs. Thus, the recognition of *L. tempanii* as a synonym of *L. vaughani* not only is logical from an analysis of the structures but also on geographic and stratigraphic considerations.

This faunal assemblage is characteristic of the uniserial *Miogypsina* subzone of the *Lepidocyclina s. s.* Zone (Cole, 1967, p. 114) or in terms of planktonic zones, the *Globorotalia kugleri* Zone. This fauna is widespread in the Caribbean region and extends southward into Ecuador.

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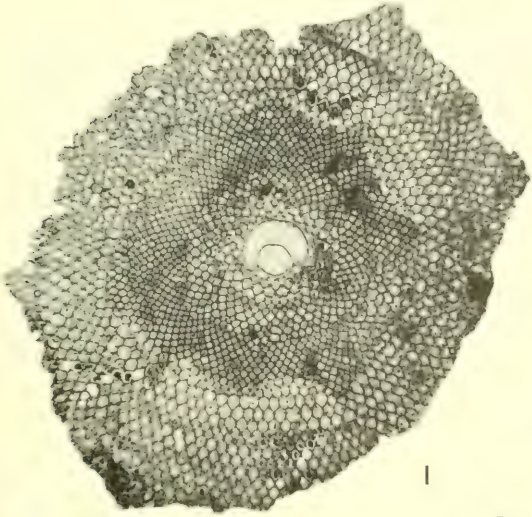
PLATES

EXPLANATION OF PLATE 19

Figure | Page

1-6. Lepidocyclina (Lepidocyclina) vaughani Cushman . **306, 307**

1. Equatorial section, X18, of a megalospheric specimen with rhombic equatorial chambers near the embryonic chambers and elongate hexagonal chambers in the peripheral zone; loc. 9 (Panama). 2. Part of an equatorial section, X72, to illustrate rhombic equatorial chambers; loc. 9 (Panama). 3. Vertical section, X18, of a well-developed megalospheric specimen to illustrate the embryonic and lateral chambers and the expanded rim; loc. 9 (Panama). 4. Part of the equatorial section, fig. 1, X72, to illustrate the change in shape from rhombic to elongate hexagonal chambers; loc. 9 (Panama). 5. Part of an equatorial section, X72, of the specimen illustrated as fig. 4, Pl. 20, to illustrate elongate hexagonal equatorial chambers of a specimen previously identified as *L. tempanii* Vaughan and Cole (1941, p. 75) for comparison with similar chambers, fig. 4, of a specimen identified as *L. vaughani*; loc. 11 (Trinidad). 6. Part of an equatorial section, X72, of a megalospheric specimen with equatorial chambers some of which are rhombic whereas others are radially elongate; loc. 9 (Panama).



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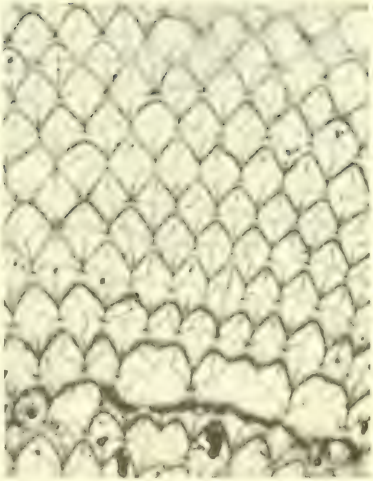

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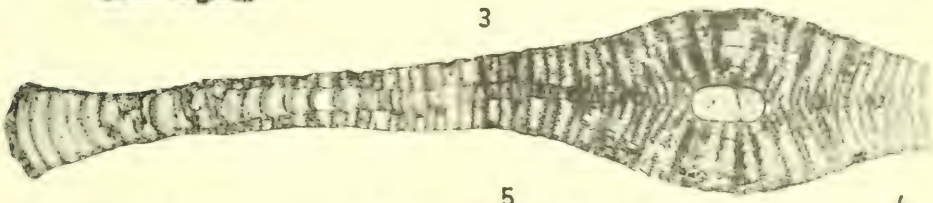

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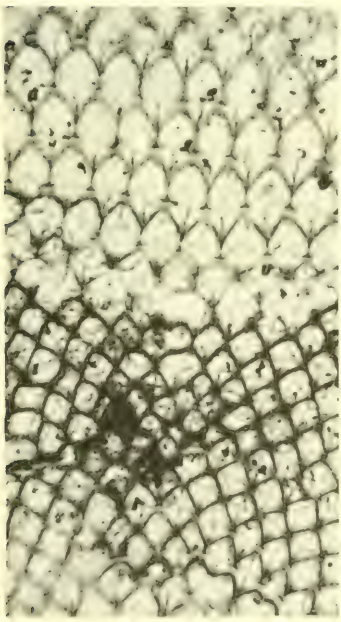

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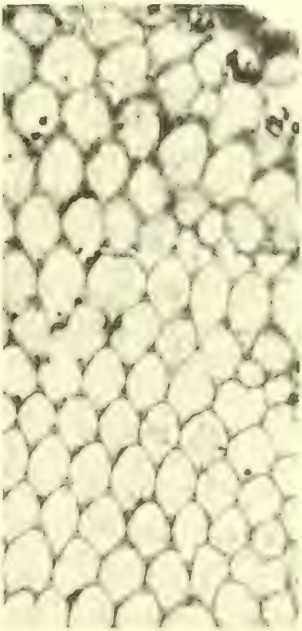

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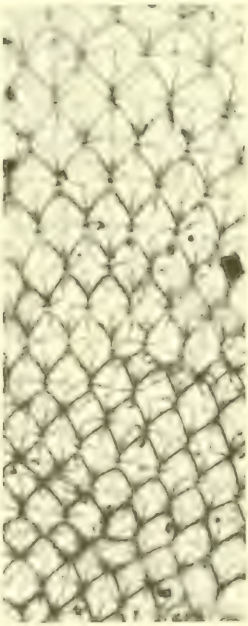

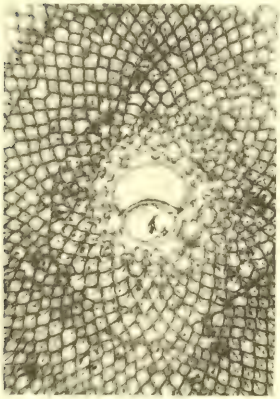

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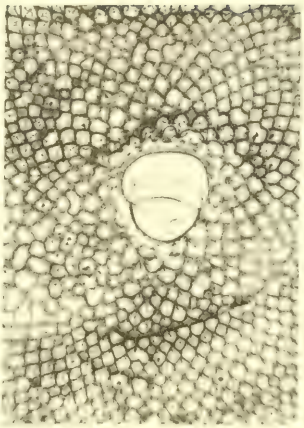

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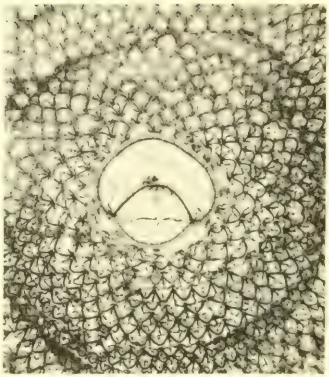

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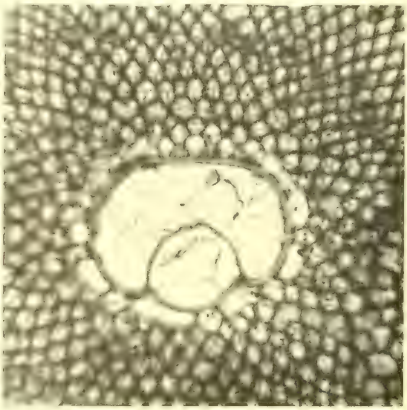

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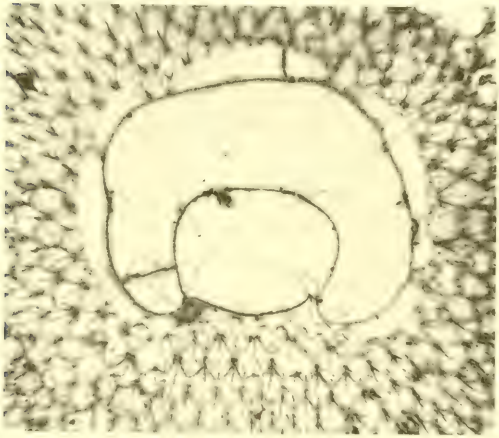
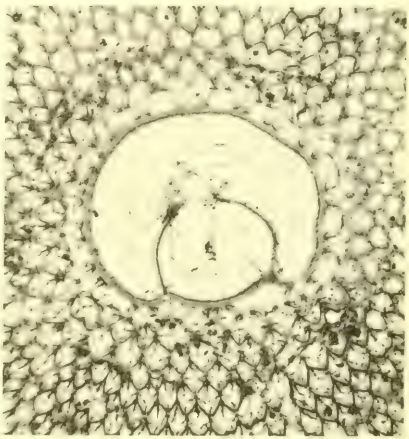




EXPLANATION OF PLATE 20

Figure — Page

1-7. **Lepidocyclina (Lepidocyclina) vaughani** Cushman 298, 299, 300, 306, 307

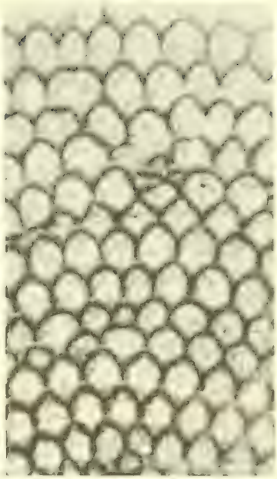
1-3, 6, 7. Parts of equatorial sections, X36, to illustrate the difference in shape and size of the embryonic chambers in specimens, all of which are from the same locality; loc. 9 (Panama). 4. Part of an equatorial section, X36, of a specimen previously identified as *L. tempanii* Vaughan and Cole (1941, p. 75); compare with fig. 3; loc. 11 (Trinidad). 5. Part of an equatorial section, X36, of a specimen identified by Vaughan (1933*a*, p. 32) as *L. vaughani*; loc. 1 (Antigua).

EXPLANATION OF PLATE 21

Figure | Page

1-7. **Lepidocyclina (Lepidocyclina) vaughani** Cushman .. 300, 302, 303, 304, 306, 307

1, 2. Equatorial chambers, X72, of specimens previously identified as *L. tournoueri* Lemoine and R. Douvillé (Vaughan, 1933*a*, p. 25); loc. 6 (Mexico). 3. Equatorial chambers, X72, of a topotype of *L. tempanii* Vaughan and Cole; loc. 2 (Antigua). 4. Part of an equatorial section, X36, of a specimen with two sets of embryonic chambers which are interconnected; loc. 9 (Panama). 5. Part of an equatorial section, X36, of a specimen with trilocular embryonic chambers which result from the complete fusion of two sets of embryonic chambers; note stolons in the center of both dividing walls and the large periembryonic chambers developed on the peripheries of the large chambers at each end; loc. 9 (Panama). 6. Part of an equatorial section, X36, of a specimen with two distinct and separate sets of embryonic chambers; loc. 9 (Panama). 7. Part of an equatorial section, X36, of a specimen with a single set of embryonic chambers; loc. 9 (Panama).



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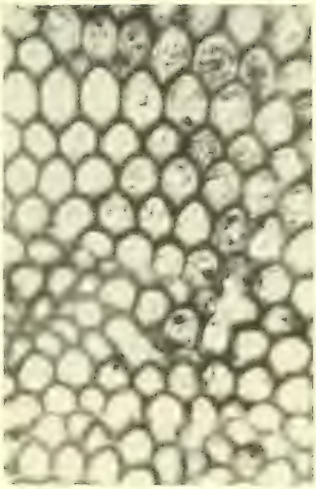

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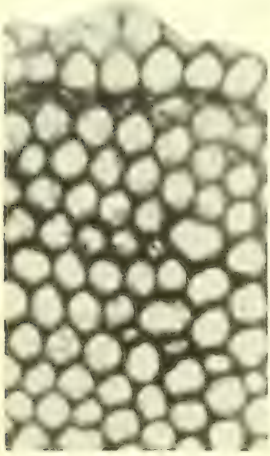

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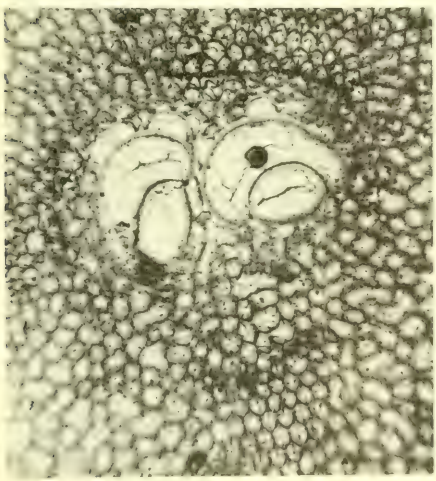

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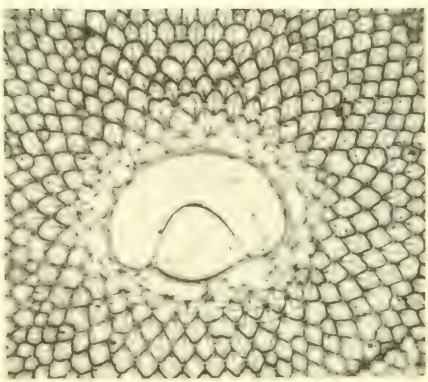

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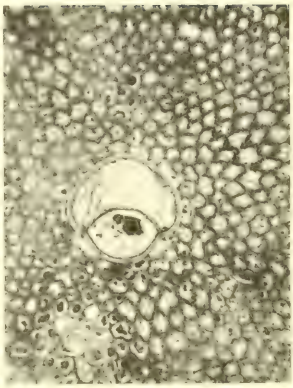

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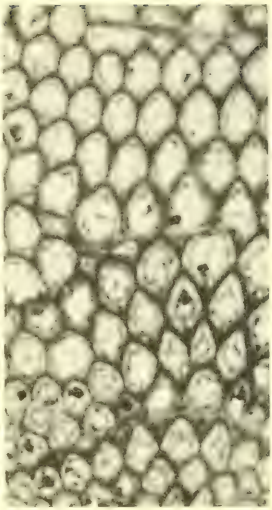

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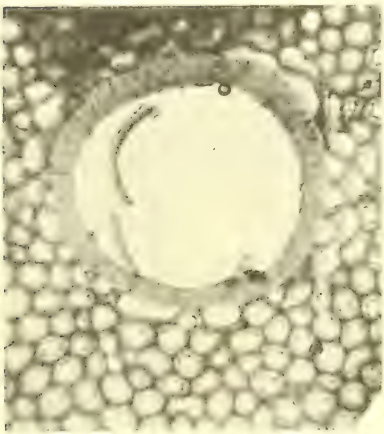

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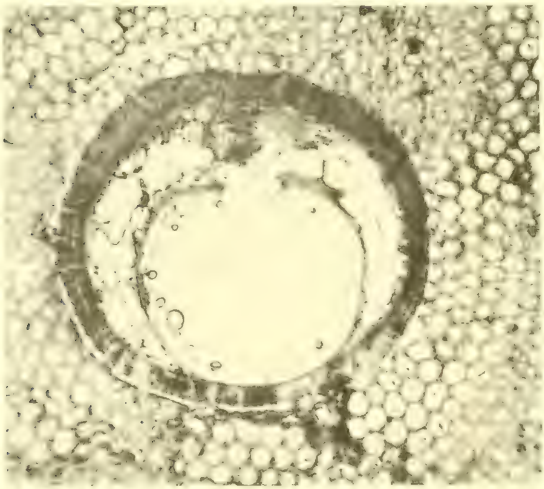

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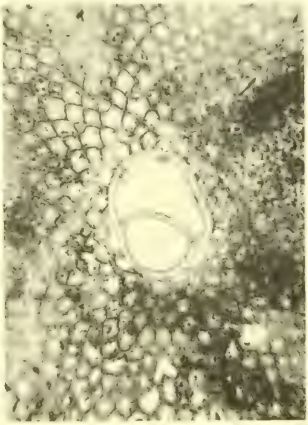


EXPLANATION OF PLATE 22

Figure — Page

1, 6, 7. Lepidocyclina (Lepidocyclina) undosa Cushman 299

1, 6. Part of equatorial sections, X36, of specimens to illustrate difference in shape and thickness of the wall of the embryonic chambers; loc. 4 (Florida). 7. Part of an equatorial section, X18, to illustrate a specimen with embryonic chambers similar to those of the specimen, fig. 6, but over twice as large; loc. 7 (Mexico).

2-5, 8. Lepidocyclina (Lepidocyclina) vaughani Cushman 300, 305

2, 8. Parts of equatorial sections, X36, of specimens previously identified as *L. dartoni* Vaughan, a stellate form, to emphasize that these specimens have the same internal structure as specimens previously identified as *L. tempanii* and *L. tournoueri*; loc. 8 (Panama). 3. Equatorial chambers, X72, of a stellate specimen previously identified as *L. dartoni*; compare with fig. 4, Pl. 19, and figs. 1-3, Pl. 21; loc. 8 (Panama). 4. Part of an equatorial section, X36, of a specimen previously identified as *L. tournoueri* Vaughan 1933*a*, p. 25); loc. 6 (Mexico). 5, Vertical section, X18, of a stellate specimen previously identified as *L. dartoni*; loc. 8 (Panama).

EXPLANATION OF PLATE 23

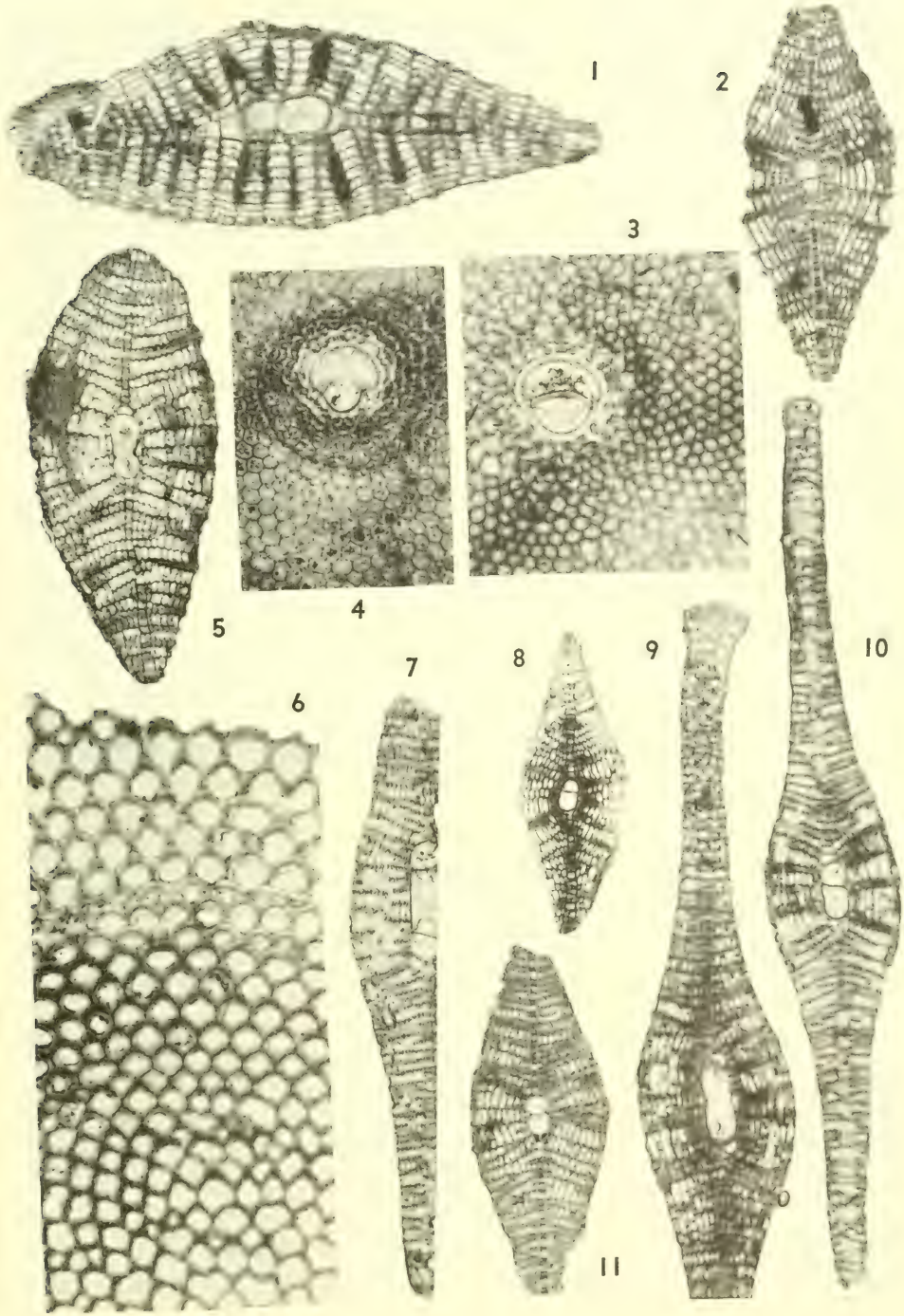
Figure — Page

1-7, 9-11. **Lepidocyclina (Lepidocyclina) vaughani** Cushman — 306, 307

1, 5, 11. Vertical sections; 1, 5, X36; 11, X20 of specimens previously identified as *L. tempanii* Vaughan and Cole (1941, p. 75); compare with the central area of figs. 9, 10; 1, 5, loc. 11 (Trinidad); 11, loc. 12 (Trinidad). 2. Vertical section, X18, of a specimen previously identified as *L. tournoueri* Lemoine and R. Douvillé (Vaughan, 1933*a*, p. 25); compare with other vertical sections of this plate; loc. 6 (Mexico). 3. Part of an equatorial section, X36, of a specimen previously identified as *L. tournoueri* Lemoine and R. Douvillé (Cole, 1952, p. 28) with hexagonal equatorial chambers; loc. 10 (Panama). 4. Part of an equatorial section, X36, of a topotype of *L. tempanii* Vaughan and Cole which is similar to the specimen, fig. 3; loc. 2 (Antigua). 6. Part of the equatorial section (Cole, 1961, pl. 16, fig. 1) enlarged, X72, to illustrate the equatorial chambers of a European specimen of *L. tournoueri* Lemoine and R. Douvillé; loc. 5 (France). 7. Half vertical section, X18, of a specimen with trilocular embryonic chambers similar to those shown by fig. 5, Pl. 21; loc. 9 (Panama). 9,10. Vertical sections, X18; 9, loc. 1 (Antigua); 10, loc. 9 (Panama).

8. **Lepidocyclina (Lepidocyclina) yurnagunensis** Cushman — 299

Vertical section, X18, introduced for comparison with vertical sections of *L. vaughani*; loc. 3 (Cuba).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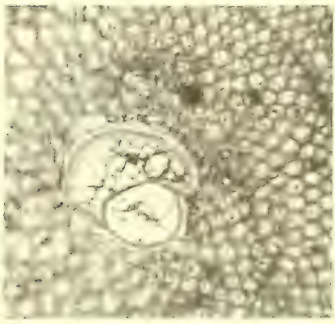

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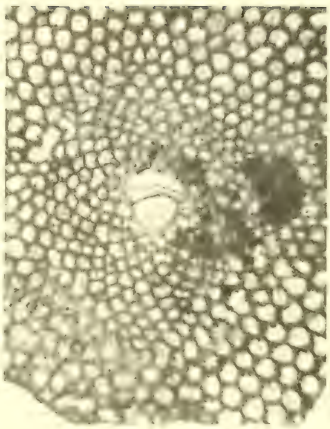

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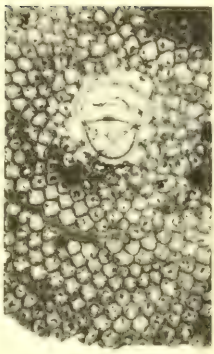

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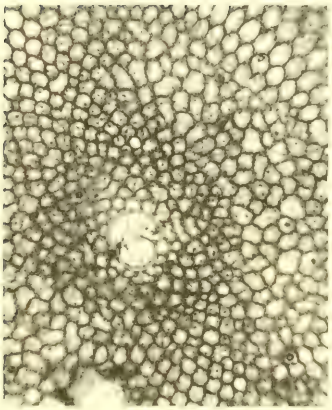

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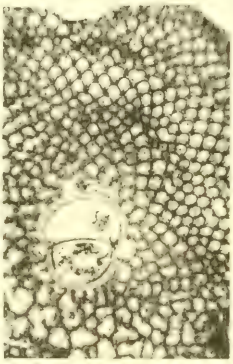

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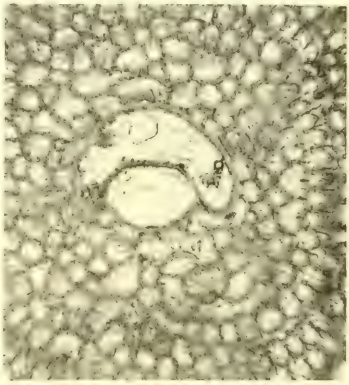

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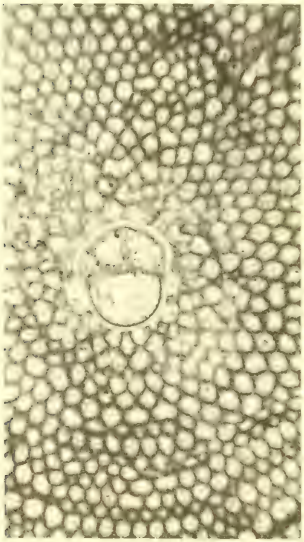

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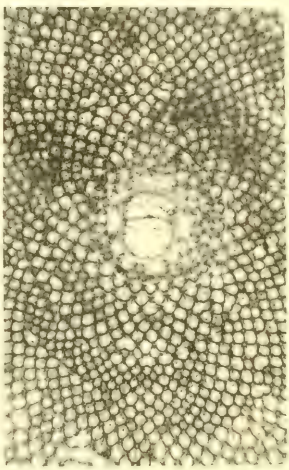

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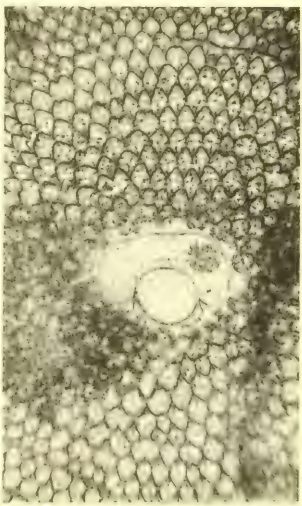

EXPLANATION OF PLATE 24

Figure — Page

1-4, 6, 7, 9. **Lepidocyclina (Lepidocyclina) vaughani** Cushman — 299, 307

Parts of equatorial sections, X36, of specimens previously identified either as *L. tempanii* or *L. tournoueri* to illustrate the shape and size of the embryonic and equatorial chambers; 1, 3, 7 (*L. tournoueri*); 1, 3, loc. 10 (Panama); 7, loc. 6 (Mexico); 2, 4, 6, 9 (*L. tempanii*); 2, loc. 2 (Antigua); 4, 6, 9, loc. 12 (Trinidad).

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